# Wall Avoiding Balbot

**SIA LIH YIN**

**A thesis submitted in fulfillment of the requirements for the award of the degree of Bachelor of Electrical Engineering (Electronic)**

**Faculty of Electrical & Electronic Engineering**

**University Malaysia Pahang**

**NOVEMBER 2010**

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)"

Signature : ______________________________________________

Name : NOR MANIHA BINTI ABDUL GHANI

Date : 22 OCTOBER 2010

"I hereby declared that this titled 'Wall Following Balbot' is the result of my own effort except as clearly cited in the reference."

Signature : ………………………………….

Name of Author : SIA LIH YIN

Date : 22 OCTOBER 2010

# AKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people such as lecturers, lab assistant and fellow colleagues. My first appreciation would definitely my supervisor, Madam Normaniha Binti Abdul Ghani. Here I would like to express my sincere appreciation for her guidance, wisdom, endurance, advices, motivation and encouragement throughout the project.

I would like to thank all my fellow friends for their contribution in giving me a moral support throughout the project environment period. Last but not least, to all my beloved family members who were always by my side to encourage, advice, cherish and support me during this project.

# Abstract

In this project, a wall avoiding Balbot is presented. The purpose of this project is to develop a path control algorithm in Balbot so that it will avoid wall when at certain range of distance. The Balbot performs the task based on the sensorial information given by two IR sensors. Atmel Atmega32 microcontroller as its brain, Atmega32 receives input from IR distance sensor and then a control signal is generated to control the mobile robot's position. The Balbot is drive through to the wall, the sensor will detect the distance and Balbot will turn to the right side to avoid the wall.

**Abstrak**

Projek ini mengenai “Wall Avoiding Balbot”. Tujuan bagi projek ini adalah untuk memperkembangkan satu algorithm untuk mengawal lorong perjalanan Balbot supaya ia boleh mengelak dinding semasa menemui jarak yang tertentu. Dengan menerima sensor informasi daripada two IR sensor, Balbot akan bergerak mengikuti algorithm lorong perjalanan. Atmel Atmega32 mikrocontroller sebagai pusat system Balbot, ia menerima maklumat daripada IR jarak sensor dan satu isyarat kawalan akan dihasilkan untuk mengawal kedudukan Balbot. Balbot sepatutnya akan bergerak sehingga menemui dinding kemudian megelak dinding dengan berpusing ke arah kanan.

## TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| TWIP | - | Two Wheeled Inverted Pendulum |
| IR | - | Infrared |
| I2C | - | Inter Integrated IC |
| BPC | - | Balance Processor Chip |
| LQR | - | Linear Quadratic Regulator |
| PID | - | Proportional Integral Derivative |
| LS | - | Left Sensor |
| RS | - | Right Sensor |
| CV | - | Control Variable |
| SP | - | Set Point |
| PV | - | Process Value |

| | | |
|---|---|---|
| LED | - | Light Emitting Diode |
| FR | - | Front Right |
| FL | - | Front Left |
| MIPS | - | Microprocessor without Interlocked Pipeline Stages |
| EEPROM | - | Electrically Erasable Programmable Read Only Memory |
| SRAM | - | Static Random Access Memory |
| DAC | - | Digital Analog Converter |
| PWM | - | Pulse Width Modulation |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Project Background

Two wheeled balancing robot is known as a robot that is capable to balance upright on its two wheels. This type of robot encourages many growth of helpful and attractive designs such as Segway which make two wheeled robot until become a commercial success. Segway had shown that a comfortable mobility opportunity for old fork and people with disability thus improving the individual sense of independence at the same time.

Stability of these robots is maintained using the inverted pendulum theory. This theory principle is to keep the wheels beneath the centre of the robot chassis's mass. When the robot begins to tilt forward, the wheel will need to move forward to return beneath the chassis mass, so the robot stability can be maintained. If this is not maintained, the robot will fall down.

In this project, Balbot [1] is an autonomous robot that will balance on its own two wheels. Balbot will try to keep itself upright by rotating its two wheels in the appropriate direction. The entire robot is completely autonomous and therefore has all of its systems onboard and powered through its own power supply. The ability balance of Balbot is accomplished by using an accelerometer and a gyroscope to determine the platform tilt in order to drive the wheels.

## 1.2 Problem Statement

The problem statements of this project are as shown below:

1. To develop a path control algorithm for the purpose of wall following of two wheels balancing robot.
2. To navigate the wall following Balbot in balance condition.

## 1.3 Objective of the Project

The objectives of this research are as follows:

1. To navigate the Balbot so that it is able to drive straight ahead, turn right and avoid wall.
2. To develop a path control algorithm for position control mobile robot.

## 1.4 Scope of the Project

The following scopes have been identified in order to achieve the objectives:

1. The Balbot must drive straight ahead, turn right and avoid wall.
2. The two IR sensors should be able to detect and perform navigation task in the environments with wall avoiding tasks.
3. To develop and burn new programming into Atmel Atmega32 microcontroller so that Balbot can perform the wall avoiding task based on signal sensorial information detected the two IR sensors.

## 1.5 Project Work Flow

The development of this project has been simplified into flow chart in Figure 1.1. It begins with the brainstorming on the project title and searching information from the journal, books, thesis and internet. The review is about path planning and path control algorithm in a mobile robot.

The project was begun by finding the idea and concept related to this project title. The wall following Balbot is depending on how it will be programmed so that it can implement the behaviors like moving left side parallel to a wall edge with a certain distance between wall and its body.

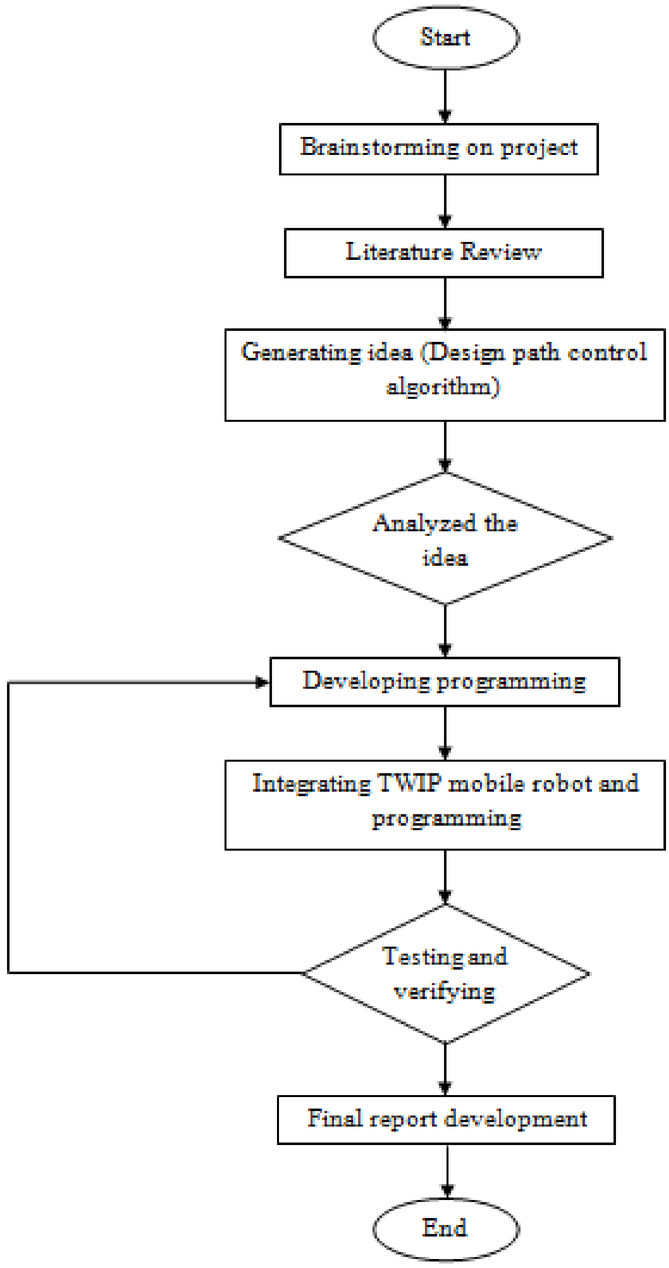


Figure 1.1: Project Work Flow

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Overview

This chapter is discusses about the previous project work that is similar to Two Wheeled Inverted Pendulum and type of linear controller that control the mobile robot. A general explanation on the stability of mobile robot and path planning are discussed.

## 2.2 Two Wheeled Balancing Robot

The concept of balancing robot is based on the inverted pendulum model. This model has been widely used by researches around the world in controlling a system not only in designing wheeled robot but other types of robot as well such as legged robots. Researchers at the Industrial Electronics Laboratory at the Swiss Federal Institute of Technology have built a prototype two wheel robot in which the control is based on a Digital Signal Processor. A linear state space controller using information from a gyroscope and motor encoder sensors is being implemented to make this system stabilize. (Grasser 2002).

Figure 2.1: Joe

Another TWIP mobile robot, Segway (Segway 2008) is the commercially available two wheeled robot that is currently in its 2nd generation of released models. It is marketed to the world as a transport alternative with the image contained within the following figure. Its advertising suggests the robot is ideal for adventure, commuting, law enforcement and transportation in general. Its trajectory control is based on the tilting direction of the handlebars which is provided by the rider.

Figure 2.2: Segway

David Anderson (2007), has developed the robot named nBot. This robot uses a gyroscope and accelerometer whose outputs are combined together by a Kalman filter, thus providing an accurate input to control the stability. This robot has won the

NASA cool robot of the week in year 2003. This robot has the ability to cross rough terrain and even travel down sets of stairs.

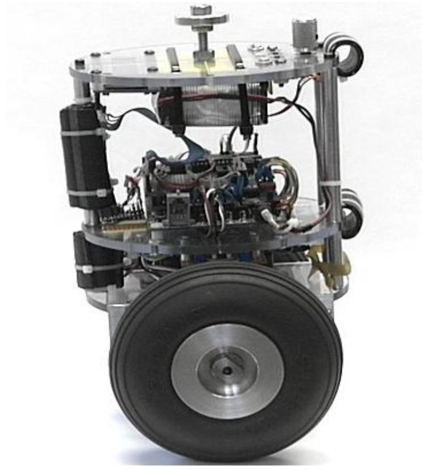

Figure 2.3: nBot

Similarly, Rich Chi Oii (2003) discusses the processes developed and considerations involved in balancing a two-wheeled autonomous robot based on the inverted pendulum model. The experimental examines the suitability and evaluates the performance of a Linear Quadratic Regulator (LQR) and a Pole-placement controller in balancing the system. The LQR controller uses several weighting matrix to obtain the appropriate control force to be applied to the system while the poles of the system is required by the Pole placement to be placed to guarantee stability.

The paper [2] describes the control of two-wheeled autonomous balancing robot. The navigation of the robot is controlled by operator by using RC remote controller. The robot has the ability to balance itself while moving and turning on a flat terrain. According to the paper, the system is based on two distance measuring sensors (Sharp GP2D12) to detect the current position and tilting angle of the robot. PID control algorithm that implemented on this project is to pilot the motors so as to stabilize the robot and stand it upright.

In paper [3], figure 2.4 shows a solution for wheels-driven mobile robot inverted pendulum which applied a neural network to solve the problem in almost all spheres of science and technology. Neural network can be a solution for balancing the pendulum and tracking the desired trajectory of the cart at the same time to achieve real time control. Neural network controllers capable to control the system along the primary proportional integral differential (PID) controllers by compensated for uncertainties in dynamics in online adaptive fashion. The neural network controller successfully controls both the balance of the pendulum and the position mobile robot without any knowing any dynamics of the system compared to PID controller where it is goes unstable when impacts occurs.

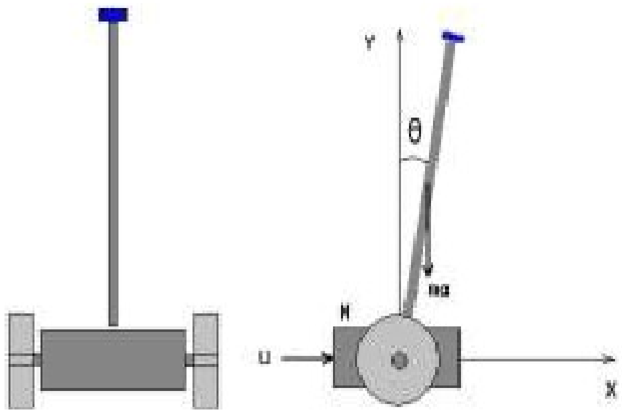


Figure 2.4: Wheels-Driven Mobile Robot Inverted Pendulum

In [4] is proposed an autonomous mobile robot equipped with two IR proximity sensors. These two sensors are simple and low-cost sensing modalities to perform local navigation tasks in environment when meet with obstacles. The IR sensors are mounted in the left and right front of the robot as shown in Figure 2.5. The emitter will send the signal to the flat floor surface and the distance of surface is calculated by depending on the signal reflected back to the IR sensors.

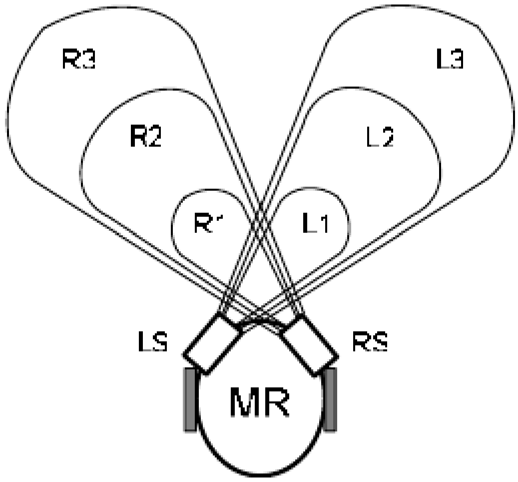


Figure 2.5: The positions of IR sensors (Mounted in front of the robot body).

The flow chart presented in Figure 2.6 show if neither sensor detects an obstacle then the robot moving will be set at maximum speed. When one sensor detects one obstacle, at level L1 and R1, the robot will turn left or right. When one sensor detects one obstacle, at level L2 and R2, the robot will move in slow speed. When one sensor detects one obstacle, at level L3 and R3, the robot will move in medium speed.